ISBN : 978-602-9030-49-5

# PROSIDING

## Bidang: Rekayasa dan Bioteknologi Pangan (Bagian 2)

## SEMINAR NASIONAL PATPI 2013

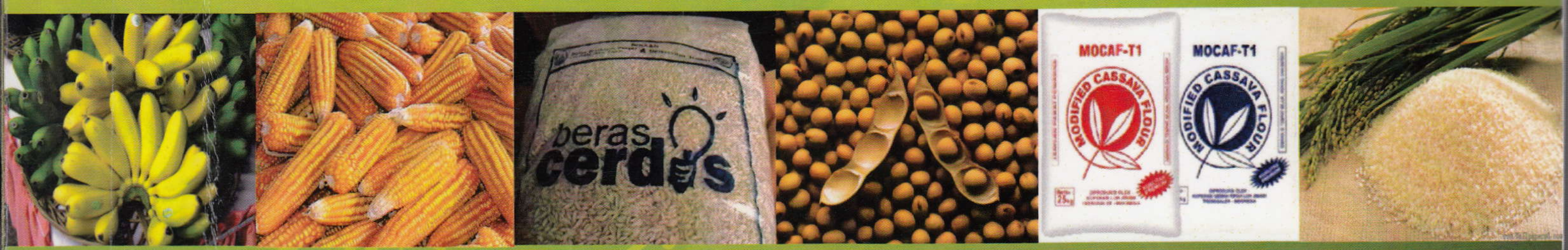
"Peran Teknologi Dan Industri Pangan Untuk Percepatan Tercapainya Kedaulatan Pangan Indonesia"

Disponsori Oleh: tps food | PT. TIGA PILAR SEJAHTERA FOOD Tbk.

## HOTEL ASTON

**Jember | 26-29 Agustus 2013**

SEMINAR NASIONAL
PATPI 2013




Disponsori Oleh:

tps food

PT. TIGA PILAR SEJAHTERA FOOD Tbk.
www.tigapilar.com

Diselenggarakan Oleh:

Patpi
Cabang Jember

IKATAN ILMUWAN INDONESIA INTERNASIONAL

# OPTIMIZATION OF DRIED SORGHUM NOODLE PROCESSING

**Tjahja Muhandri[1)2)], Subarna[1)], BudiNurtama[1)]**
1) Peneliti di SEAFAST Center - IPB
2) Peneliti di SEAMEO - BIOTROP

## ABSTRACT

Researches on the process of sorghum noodles making, particularly using appropriate varieties, have not much done in Indonesia. The purpose of this study is to observe the characteristics of the five varieties of sorghum and optimization of sorghum noodle manufacturing process by using a single screw cooking-forming extruder. Proximate analysis, amylose content and starch pasting properties have been conducted on five varieties of sorghum. Response Surface Methodology (RSM) was applied in the optimization process in which cooking loss and elongation were responses measured. Two process variables used for the extruder are temperature of 80-95 ° C and screw speed of 50-125 rpm. Based on the analysis results of amylose content and pasting properties, the five varieties have a potential use for making sorghum noodle. The optimum process condition is a temperature of 95 ° C with a screw speed of 125 rpm.

**Keywords**: process optimization, Response Surface Methodology, sorghum noodle, extruder

## BACKGROUND

The use of pasta extruder, commonly used for making spaghetti or vermicelli, such as by Waniska *et al.* (1999) is less suitable because the extruder does not have compression section in its screw configuration. The dough gains less shear pressure and the flour granules breaking does not occur optimally.

Another drawback of pasta extruder is not equipped with a heater; the dough should be gelatinized (heated) first so it is hot and sticky and it is hard to put the batter into the zone of extruder feeding. Screw speed are constant (uncontrollable) and the screw design that has a fine surface causes the dough slipped and is not pushed maximally to the die.

Characteristics of a good quality in non-wheat noodles can be achieved when the dough undergo gelatinization, pressure and enough shear stress (Charutigon *et al.*, 2007; Marti *et al.*, 2010; Marti *et al.*, 2011). Marti et al. (2010) stated that rice noodles processed by cooking-forming extruder, have a cooking loss of 4.2%, much lower than the cooking loss of noodles made by pasta extruder that is 15.9%. It is caused by inadequate levels of gelatinization and shear stress.

Suhendro *et al.* (2000) reported that sorghum noodles had good results from three passed pasta dough in the extruder. Marti *et al.* (2011) stated that during the process of extrusion-cooking pasta, high temperature and shear stress cause gelatinization and starch granule breakdown. After retrogradation, starch polymers will bind again and produce a new matrix structure.

Muhandri (2011) stated that the making of noodles from corn starch flour requires gelatinization mechanism and breaking of flour granules which are necessary to form hydrogen bonds between amylose during retrogradation (cooling). The hydrogen bonds will form a structure of sturdy noodle. This condition requires sufficient temperature, optimal moisture content and appropriate shear pressure. Hydrogen bonding between amylose is also determined by the amylose content of the flour.

Varieties of sorghum which are suitable for making noodle are not yet known. According to Tam *et al.* (2004), amylose content of flour for making noodle is between 27-

29%, while according to Muhandri (2012) it is about 30%. Therefore, it is necessary for stages of selection of sorghum varieties.

## METHODS

### Preparation of Sorghum Flour

Sorghum flour is prepared by the modification of dry milling method that has been done by Muhandri (2012). The method consists of polishing, soaking, draining, grinding (disc mill with 48 mesh sieve), drying of flour, sieving of flour (100 mesh), and drying the flour after sieving.

### Characterization of Sorghum Flour

Characterization of sorghum flour involved proximate analysis, amylose content and pasting properties used rapid visco analyser. The objective of this stage is to find sorghum flours that appropriate for sorghum noodle.

### Optimization of Sorghum Noodle Processing

The stages of sorghum noodle production consist of mixing, extrusion, and drying. Sorghum flour (100 mesh), salt 2%, and aquades 55% was mixed using hand mixer (5 minute). Processing uses cooking-forming single screw extruder. Procces variables are extruder temperatures (80, 85, 90, 95°C) and screw speeds (50, 75, 100, 125 rpm). Sorghum noodle is dried using air drier for 2 days.

### Analyses and Measurements

#### Proximate and amylose analysis

Sorghum flour and starch are analyzed for the proximate and amylose content with two replications. These analyses are used as basic information of the flour and starch. The analyses are water content using oven method (AOAC, 1995), ash content (AOAC, 1995), fat content using Soxhlet method (AOAC, 1995), protein content using Micro-Kjeldahl method (AOAC, 1995), carbohydrate content (by difference), total starch analysis (AOAC, 1995) and analysis of amylose (Apriyantono *et al.*, 1989).

#### Analysis of gelatinization profile

The analysis uses rapid visco analyzer.

#### Physical analysis of sorghum noodle

Physical analysis of the sorghum noodles consists of cooking loss and elongation analysis, using a Texture Analyzer for dried noodles.

#### a). Measurement of Cooking Loss (Oh *et al.*, 1985)

Determination of cooking loss is done by boiling 5 grams of noodles in 150 ml of water for 6 minutes and drained. Then the noodle is dried at 100°C until constant weight, and then weighed again. Water content of the other noodle (about 5 grams) is measured (the data will be used to calculate the dry weight of the sample). Cooking loss (CL) is expressed as follow:

$$CL (\%) = \frac{\text{Dry weight before boiling - Dry weight after boiling}}{\text{Dry weight of sample before boiling}} \times 100\%$$

#### b). Elongation analysis using Texture Analyzer

Samples are wrapped around the probe with a probe distance of 2 cm and the speed of the probe is 0.3 cm/s. Percent elongation is calculated using the formula:

$$\%\ \text{Elongation} = \frac{\text{Breaking time of sample (sec)} \times 0.3\ \text{cm/sec}}{2\ \text{cm}} \times 100\%$$

## RESULTS AND DISCUSSION

### 1. Proximate analysis

Results of the proximate analysis and the amylose content are presented in Table 1. Protein content of five varieties of sorghum showed that protein levels are in the range of 8.14 to 8.50%. This value indicates the potential of sorghum as a food source with high protein content.

**Table 1**. Results of proximate analysis

| Variety | Water content (%) | Protein (%) | Fat (%) | Ash (%) | Carbo-hydrate (%) | Starch (% carbo-hydrate) | Amylose (% carbo-hydrate) |
|---|---|---|---|---|---|---|---|
| Numbu | 15.63±0.11 | 8.50±0.27 | 2.42±0.11 | 0.84±0.06 | 72.61±1.03 | 82.18±0.06 | 22.46±1.23 |
| Durra | 15.66±0.15 | 8.19±0.02 | 1.09±0.06 | 0.84±0.05 | 74.21±0.23 | 87.42±0.15 | 24.29±0.26 |
| UPCA-S1 | 17.38±0.01 | 8.40±0.71 | 1.01±0.02 | 0.83±0.02 | 72.37±1.12 | 83.75±1.20 | 24.31±0.55 |
| B-100 | 16.68±0.17 | 8.22±0.02 | 0.67±0.03 | 0.74±0.07 | 75.70±0.02 | 82.43±0.00 | 26.43±0.50 |
| B-95 | 18.59±0.14 | 8.14±0.06 | 0.44±0.03 | 0.93±0.03 | 71.90±2.20 | 79.22±3.91 | 26.31±0.05 |

The carbohydrate contents were determined by difference. The calculation method is the determination of the levels of carbohydrates roughly and results are generally listed in the list of composition of the food. Carbohydrate levels in sorghum flour ranged between 79.22 – 87.42% dry basis which shows carbohydrate as the most dominant content in sorghum flour.

Different starch content may cause differences in the characteristics of the flour itself. This is due to a comparison of the content of amylose and amylopectin starch. Determination of appropriate varieties to be made into noodles is based on the content of amylose (Tam *et al.*, 2004). Amylose content of sorghum flours range between 22.46 – 26.43% dry basis which is still the normal range, i.e., 20-30%. Amylose content ranging from lowest to highest successively owned by the sorghum varieties of Numbu, UPCA-S1, Durra, B-95, and B-100. The five varieties have amylose contents that suitable for noodle products with extrusion technology. Numbu variety was selected in the next process for reasons of availability and ease in obtaining raw materials.

### 2. Pasting Properties

Rheological properties and gelatinization profiles of starch from sorghum flour is observed using Rapid Visco Analyzer. The principle of the RVA itself is almost the same with Brabender Amylograph which is mostly used to view the profile of starch gelatinization. The purpose of analysis of starch gelatinization is to know the process of starch gelatinization when starch suspension is heated and cooled at constant rate of temperature and changes per unit of time. In general, a suspension of starch will be gelatinized during the process of heating and form a gel after cooled. Change of physical properties of starch suspension will affect viscosity of starch suspension. The results of the analysis of gelatinization profiles for 5 varieties of sorghum flour can be seen in Table 2 and Figure 1.

**Table 2.** Gelatinization profile of five varieties of sorghum flour

| | Variety | | | | |
|---|---|---|---|---|---|
| **Parameter** | **Numbu** | **Durra** | **UPCA-S1** | **B-100** | **B-95** |
| Time of gelatinization (minutes) | 5.30 | 5.00 | 5.00 | 5.20 | 5.00 |
| Temperature of gelatinization (°C) | 77.53 | 75.48 | 78.73 | 75.50 | 77.33 |
| Time of broken granule (minutes) | 8.24 | 8.14 | 8.27 | 8.20 | 8.10 |
| Maximum viscosity (cP) | 3167.50 | 3381.00 | 3372.50 | 3789.50 | 3158.00 |
| Temp. of broken granule (°C) | 94.00 | 94.00 | 94.00 | 94.00 | 93.00 |
| Viscosity at 95°C (cP) | 1743.50 | 1955.00 | 1998.50 | 2197.50 | 1892.00 |
| Breakdown viscosity (cP) | 1424.00 | 1426.00 | 1374.00 | 1591.50 | 1266.00 |
| Viscosity at 50°C (cP) | 4101.00 | 3793.00 | 4046.50 | 4166.50 | 3559.00 |
| Setback viscosity (cP) | 2357.50 | 1838.00 | 2048.00 | 1969.00 | 1667.00 |

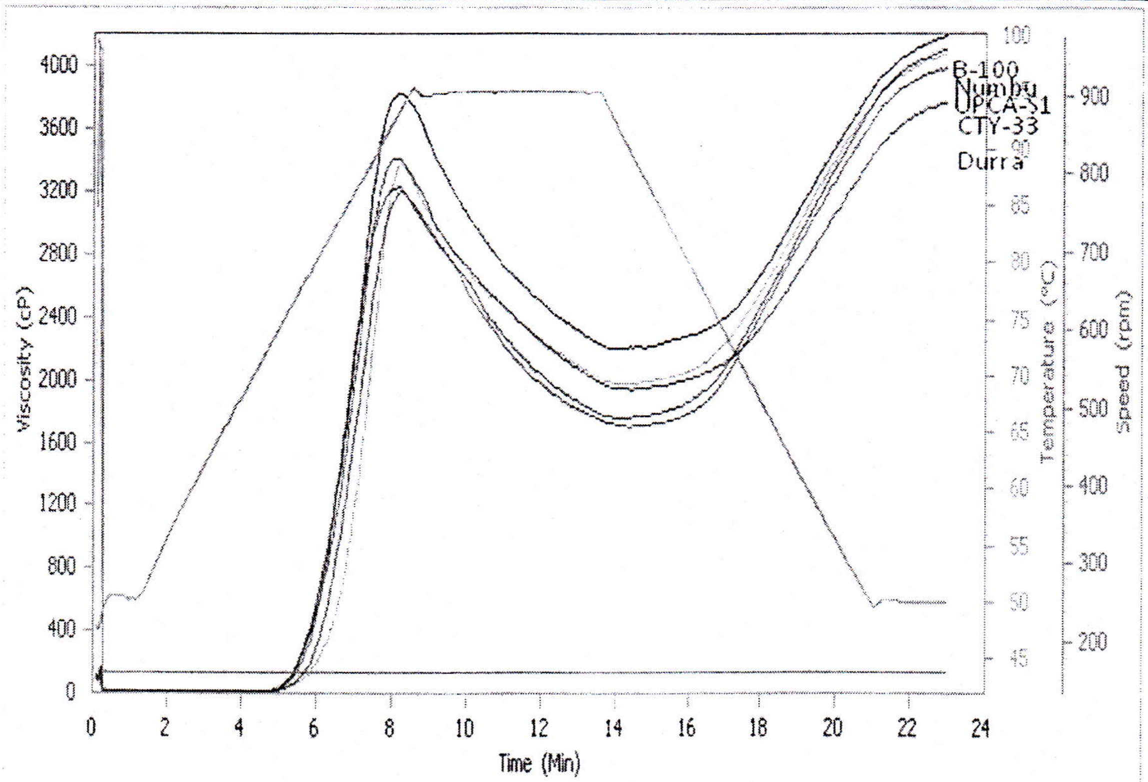



**Figure1.** Gelatinization profile of five varieties of sorghum flour

### 3. Optimization Of Sorghum Noodle Process Using Single Screw Extruder

Making the dough of dried sorghum noodle is started by weighing the materials to be used, i.e. sorghum flour, salt, and water. Salt added is 2% from the weight of the flour. This refers to corn noodle research by Muhandri *et al.* (2011). For each treatment, used sorghum flour as much as 160 grams. Water used is influenced by water content of sorghum flour and the ability of the flour to absorb water (known as water absorption). Previously, it was conducted an experiment to determine the amount of water is added to the sorghum flour that has a moisture content of 11-12%. The results of the experiment are shown in Table 3.

Process variables in the optimization of dry sorghum noodles making are presented in Table 4. Samples of noodles were taken from each treatment of temperature and screw speed combination and were analyzed for cooking loss and percent elongation. The noodles must be cooked until done before analyzed. Determination of cooking time is done by cooking the noodles and tasted it every 1 minute until the noodles are cooked perfectly.

**Table 3.** Trial results of water addition to the noodle dough

| % water addition | Characteristics of dough |
|---|---|
| 50% | The dough was too dry and not moist enough, the color is bright. It may not enough to gelatinize starch in extruder. |
| 55% | The dough has sufficient levels of wet, the color is bright enough. |
| 60% | The dough is too wet and the color is too dark. It may produce a product with the darker color. |

The noodles that are processed with the extruder temperature at 80°C have 12 minutes of cooking time whereas noodles processed from extruder temperature at 95°C have 15 minutes of cooking time in boiling water (100°C). The difference is due to the diameter of the noodles; the lower extruder temperature produced the smaller diameter of the noodles. In addition, a lower extruder temperature causes a little bit brighter color of noodles than higher temperature. Therefore, it can be concluded that noodles with lower temperature have a shorter cooking time, a little brighter color, and smaller diameter.

**Table 4.** Results of the analysis of dried sorghum noodle samples.

| No. | Process variable | | Elongation (%) | Cooking loss (%) | Diameter wet noodle (mm) | Diameter dry noodle (mm) |
|---|---|---|---|---|---|---|
| | Temp (°C) | Screw speed (rpm) | | | | |
| 1 | 80 | 52-a | 186.53 | 15.47 | 2.14;2.24 | 1.17;2.17 |
| 2 | 80 | 52-b | 282.53 | 15.12 | 1.96;2.47 | 1.42;2.18 |
| 3 | 80 | 74 | 175.88 | 24.09 | 2.00;2.49 | 1.80;2.02 |
| 4 | 80 | 125-a | 122.55 | 11.63 | 2.27;2.62 | 1.87;2.15 |
| 5 | 80 | 125-b | 104.87 | 12.72 | 2.62;3.53 | 1.38;2.31 |
| 6 | 84 | 50 | 243.89 | 15.27 | 2.89;3.14 | 1.62;2.52 |
| 7 | 84 | 106 | 283.42 | 17.31 | 2.26;2.83 | 1.42;2.46 |
| 8 | 88 | 93 | 189.02 | 13.64 | 2.53;3.05 | 1.42;2.57 |
| 9 | 89 | 125 | 330.75 | 12.98 | 2.45;3.13 | 1.68;2.64 |
| 10 | 90 | 54 | 316.11 | 15.41 | 2.76;3.40 | 1.70;2.88 |
| 11 | 95 | 50-a | 382.09 | 12.58 | 2.95;3.53 | 1.56;2.53 |
| 12 | 95 | 50-b | 237.49 | 8.65 | 2.53;3.22 | 1.70;2.57 |
| 13 | 95 | 88-a | 266.81 | 8.90 | 3.02;3.57 | 1.62;2.70 |
| 14 | 95 | 88-b | 328.76 | 12.01 | 3.02;3.28 | 1.54;2.55 |
| 15 | 95 | 125-a | 339.70 | 5.33 | 2.72;3.29 | 1.63;2.83 |
| 16 | 95 | 125-b | 360.56 | 10.02 | 2.93;3.46 | 1.63;2.77 |

Diameter of noodles have measured using micrometer with accuracy of 0.05 mm. The noodles have elliptical shapes so there are two values, the shortest diameter and the longest diameter. Wet noodles have a larger diameter than dry noodles due to the water that enters into the structure and causes the noodles expand.

The results of cooking loss and elongation analysis of rehydrated sorghum noodles have been inputted into the table of Response Surface Method D-Optimal from Design Expert 7.0 software. Each of the response will then be processed in polynomial modeling ranging from the highest level i.e. "cubic" to "mean" which is the lowest level. In the selection of models, the software will suggest a model that we can use.

**Model Analysis Of Cooking Loss (CL)**

After entering the CL data value in the response variable of RSM, the suggested model is linear vs. mean. On the result of ANOVA, model that is able to meet with the three criteria is Linear. Although the value of $R^2$ from the model under 0.6000 (0.5383), the linear model can meet the three criteria that must be met as well as having the highest value of $R^2$ compared to other models. In addition, Adequate Precision has a value > 4 (6.958) so the model can be used to predict the best process optimization.

Based on the results of the data processing, the linear equation has obtained from the input variables of temperature and screw speed and the response CL. The actual equation for CL of dried sorghum noodle is:

$$CL = 53.78557 - 0.42183\,(\text{temperature}) - 0.041200\,(\text{speed of screw})$$

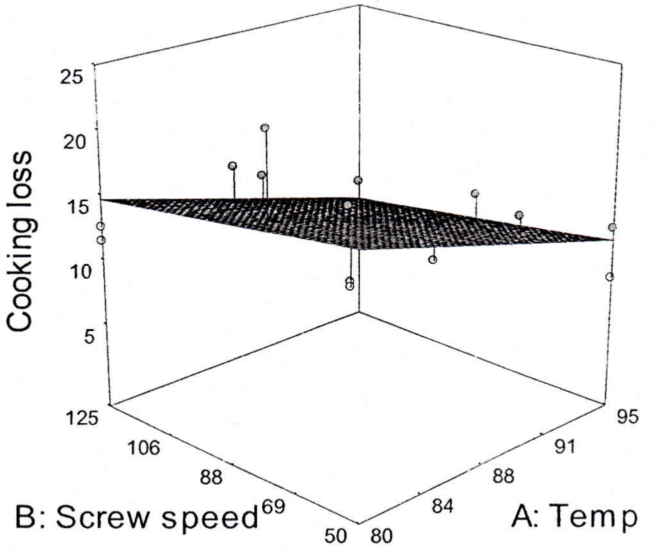



Figure2. Three-dimensional graph of cooking loss

Increasing screw speed and barrel temperature could reduce cooking loss. Increasing screw speed caused increasing of shear stress while increasing in temperature will be increased degree of gelatinization. This indicates that gelatinization is affected by temperature and pressure in the extruder (Chaudary *et al.*, 2008). Pressure and shear stress that high enough, will cause rupture of starch granules, amylose and amylopectin separated perfectly and will form a solid network during the stage of retrogradation (Muhandri *et al.*, 2011). Screw speed had affect the pressure in the extruder die (Chaudary *et al.*, 2008). Therefore, the structure of the processed noodles with pressure and shear stress were not enough, the noodles will be weak and easily broken or whole when cooked (Cheyne *et al.*, 2005).

According to Wang *et al.* (1999), cooking loss rate depends on the level of starch gelatinization, and the strength of the noodles structure. However, Charutigon *et al.* (2007) stated that the cooking loss is mainly due to the solubility of gelatinized starch, and weak bonds in the surface of noodle. High shear stress in the extruder die is needed to form strongh structure of the surface of the noodle.

**Model Analysis Of Elongation**

For the elongation response, the recommended model is Linear vs. Mean. After data processing, it has found that the model 2FI is the most appropriate model. In addition to fulfilling the three main criteria, the model also has the greatest value of $R^2$ than other models (0.6339) and Adequate Precision value is greater than 4 (7.540). Therefore, the model used for elongation response variable is 2FI.

Based on the result of the data processing, the actual equation for elongation is:

$$\text{Elongation} = 461.35053 - 2.0587\,(\text{temperature}) - 11.76695\,(\text{screw speed}) + 0.13112\,(\text{temperature} * \text{screw speed})$$

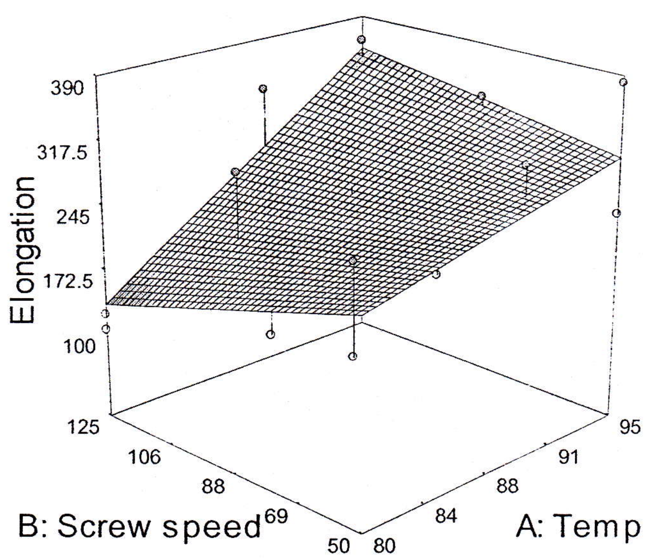



**Figure 3.** Three-dimensional graph of elongation

Noodles elongation is determined by the structure of the noodles. At high temperatures, there is a lot of gelatinized starch. At higher screw speeds, the residence time of dough in the extruder is too short (Chaudary *et al.*, 2008), so the release of amylose and amylopectin and noodles structure formation only occurs at the surface, resulting in a lower elongation.

At high temperatures, gelatinization has happened perfectly, higher screw speeds causes the release of amylose and amylopectin occur in all parts of the noodles. Structure becomes stronger throughout noodles (at retrogradration) and elongation noodles will rise.

**Numerical Optimization**

On the criteria of numerical optimization, there are four factors to be determined i.e. temperature, screw speed, CL, and elongation. For temperature and screw speed, the criteria are "in range", i.e. the expected solution has a temperature and screw speed is in the range as in the experimental design.

On the criteria of CL, the value of the desired CL is minimum. The level of "importance" is ++++. For elongation of the product, its purpose is "in range" because in general the value of elongation of the noodle has been fine and it's not broken so the elongation does not assigned specifically.

The selected process as the best solution is the process of making the dried sorghum noodles at a temperature of 95°C and screw speed 125 rpm. At that process values, the prediction value of CL is 8.56%, elongation is 351.99% with a value of desirability is 0.828. This desirability value is high enough so that the solution offered is in accordance with the objective of the optimization process.

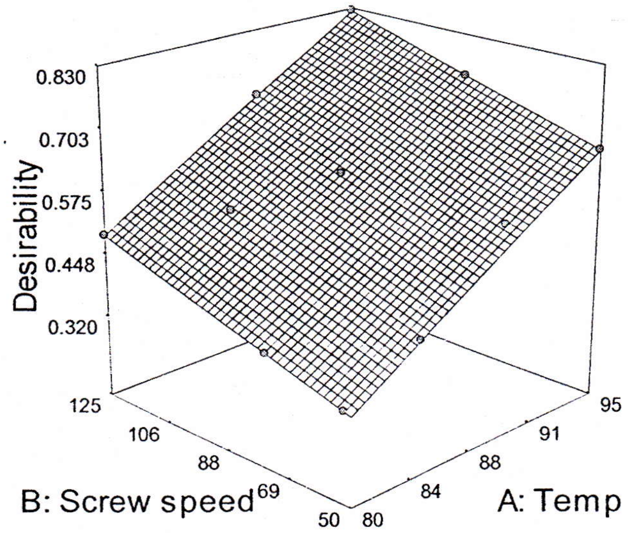



**Figure 4.** Three-dimensional graph of desirability

**Table 5.** Formula solutions offered in the optimization process

| No. | Temperature (°C) | Screw speed (rpm) | Cooking loss (%) | Elongation (%) | Desirability |
|---|---|---|---|---|---|
| 1 | 95 | 125 | 8.56 | 351.99 | 0.828* |
| 2 | 95 | 123 | 8.63 | 350.89 | 0.824 |
| 3 | 95 | 113 | 9.06 | 343.60 | 0.801 |

*Optimum Formula

**Point Prediction**

The results of the verification stage, along with predictions of each response can be seen in table 6. At this stage points prediction, program Design Expert 7.0 will give the value of CI (Confident Interval) and PI (Prediction Interval) for each value of the predicted response at 5% significance level. Confident interval is the range that shows the average expectations of the results of the next measurement on the extent of a particular significance, in which case 5%, while prediction interval is a range that demonstrates expectations the next response measurement results with the same conditions at 5% significance level. The results of the verification and prediction of each response can be seen in Table 6.

**Table 6.** Results of prediction and verification points from the selected solution

| Response | Prediction | Verification | 95% CI low | 95% CI high | 95% PI low | 95% PI high |
|---|---|---|---|---|---|---|
| Cooking loss (%) | 8.56 | 8.95 | 5.33 | 11.80 | 1.14 | 15.99 |
| Elongation (%) | 351.99 | 332.4 | 277.54 | 426.44 | 207.15 | 496.82 |

Prediction points for the response of cooking loss is 8.56% and elongation is 351.99% on dried sorghum noodle processed with extruder temperature of 95°C and screw speed of 120 rpm. While verification results of the responses of cooking loss and elongation are 7.74% and 332.4% respectively. Those results were still within the range of Confident Interval Prediction and Interval so that predictions and tangible results of solution of products offered is appropriate. Product of dried sorghum noodle with 95°C process temperature and screw speed 125 rpm will be analyzed organoleptically in the next step.

## CONCLUSION

Proximate analysis of five varieties of sorghum (Numbu, Durra, UPCA-51, B-100 and B-95) shows that the protein content of sorghum ranged from 8.14 to 8.50%, carbohydrates ranged from 79.22 – 87.42% and amylose 22.46 - 26.43%. All five varieties of sorghum have a potential characteristic as a raw material of noodles. The optimum process condition is a temperature of 95°C with a screw speed of 125 rpm. In these conditions, sorghum noodle has a cooking loss of 7.74% and elongation of 332.4%.

## ACKNOWLEDGEMENT

We thank SEAMEO BIOTROP for fund supporting and SEAFAST Center-IPB for facilitating research equipments.

## REFERENCES

AOAC. Methods of analysis. Association of Official Analytical Chemistry, Washington DC;1995.

Apriyantono A, Fardiaz D, Puspitasari NL, Budijanto S. *Petunjuk Praktikum Analisis Pangan*. IPB Press; 1989.

Charutigon C, Jintana J, Pimjai N, Vilai R. Effects of processing conditions and the use of modified starch and monoglyseride on some properties of extruded rice vermicelli. *Swiss Society of F Sci Tech*. 2007, 41:642-651.

Chaudary AL, Miler M, Torley PJ, Sopade PA, Halley PJ. Amylose Content and Chemical Modification Effects on the Extrusion of Thermoplastic Starch from Maize. Carbohydrate Polimers 2008,74:907-913.

Cheyne A, Barnes J, Gedney S,. Wilson DI. Extrusion behaviour of cohesive potato starch pastes:II. Microstructure–process interactions. *J Food Engineering* 2005, 66:13–24.

Marti A, Seetharaman K, Pagani MA. Rice-based pasta: A comparison between conventional pasta-making and extrusion-cooking. *J Cereal Chem* 2010, 83:611-616.

Marti A, Pagani MA, Seetharaman K. Understanding starch organisation in gluten-free pasta from rice flour. *Carb polym* 2011, 84:1069-1074.

Muhandri T. Karakteristik reologi mie jagung dengan proses ekstrusi pemasak-pencetak. *PhD Thesis*. Institut Pertanian Bogor, Program Studi Ilmu pangan; 2012.

Muhandri T, Ahza AB, Syarief R, Sutrisno. Optimasi proses ekstrusi mi jagung dengan metode respon permukaan. *J Teknol dan Industri Pangan* 2011, 22:97-104.

Suhendro EL, Kunetz CF, McDonough CM, Rooney LW, Waniska RD. Cooking characteristic and quality of noodles from food sorghum. *Cereal Chem* 2000, 77:96-100.

Tam LM, Corke H, Tan WT, Li J, Collado LS. Production of *bihon*-type noodles from maize starch differing in amylose content. *Cereal Chem* 2004, 82:475-480.

Waniska RD, Yi T, Wei L. Effects of preheating temperature, moisture, and sodium metabisulfite content on quality of noodles prepared from maize flour or meal. *J Food Sci. Technol* 1999, 5:339-346.